Prevalence of symptoms of vaginal fistula in 19 sub-Saharan Africa countries: a meta-analysis of national household survey data

PREVALENCE OF VAGINAL FISTULA SYMPTOMS IN 19 SUB-SAHARAN AFRICA COUNTRIES: A META-ANALYSIS OF NATIONAL HOUSEHOLD SURVEY DATA

Mathieu Maheu-Giroux[1] MSc, Véronique Filippi[2] PhD, Sékou Samadoulougou[3] MSc, Marcia C Castro[1] PhD, Nathalie Maulet[4] MSSc MPH, Nicolas Meda[5,6] MD PhD, and Fati Kirakoya-Samadoulougou[2]* PhD

1-Department of Global Health & Population, Harvard School of Public Health, 665 Huntington Avenue, Boston MA 02115, USA.

2-London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, United Kingdom.

3-Pôle Epidémiologie et Biostatistique, Institut de Recherche Expérimentale et Clinique, Faculté de Santé Publique, Université catholique de Louvain, Clos Chapelle-aux-champs 30, B1.30.13, 1200 Brussels, Belgium.

4-Institute of Health and Society, Université Catholique de Louvain, Clos Chapelle-aux-champs 30, B1.30.16, 1200 Brussels, Belgium.

5-Centre Muraz, Ministry of Health, 01 PO Box 390, Bobo-Dioulasso, Burkina Faso.

6- Université de Ouagadougou, 03 PO Box 7021, Ouagadougou, Burkina Faso.

* Corresponding author: fati.kirakoya@lshtm.ac.uk

ABSTRACT

Background: Vaginal fistula (VF) is a serious medical condition characterized by an abnormal opening between a women's vagina and bladder and/or rectum that results in continuous leakage of urine and/or stool. The knowledge base regarding the magnitude of the burden of this condition in sub-Saharan Africa is scarce. The aim of this study is to determine the lifetime and point prevalence of VF symptoms in women of reproductive age in sub-Saharan Africa.

Methods: All Demographic and Health Surveys (DHS) and Multiple Indicators Cluster Surveys (MICS) surveys from sub-Saharan Africa were considered. We included 19 surveys in our meta-analyses of lifetime and point prevalence, totaling 262,100 respondents. Pooled prevalence estimates were obtained using Bayesian hierarchical meta-analysis models that adjusted for the imperfect accuracy of the survey instruments and that imputed missing observations (for point prevalence).

Findings: Lifetime prevalence was estimated at 3·0 per 1,000 women of reproductive age (95%Credible Interval [CrI]: 1·3-5·5). After imputation of missing information, point prevalence was estimated at 1·0 case per 1,000 women (95%CrI: 0·3-2·4). Ethiopia has the largest number of women who currently experience VF symptoms.

Interpretation: This study is the first to estimate the burden of VF in 19 sub-Saharan Africa countries using nationally representative survey data. Point prevalence is slightly lower than previously estimated but these previous figures are well within the prevalence's credible intervals.

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INTRODUCTION

Vesico- or recto-vaginal fistula, hereafter referred to as vaginal fistula (VF), is a serious medical condition characterized by the presence of an abnormal opening (fistula) between a woman's vagina and bladder and/or rectum. VF in poor resource settings usually result from prolonged or obstructed labor (obstetric fistula) but can also be the consequence of sexual assault or inadvertent injuries during surgery/operation, among other reasons. It is a highly debilitating condition, with women often ostracized because of the resulting constant leakage of urine and/or stool through the vagina [1,2]. Eliminating obstetric fistula has been on the agenda of the United Nations Population Fund (UNFPA), through its *Campaign to End Fistula*, and the United States Agency for International Development (USAID) program for almost a decade now [3,4]. Quantifying progress through reliable health indicators remains elusive, however. Currently, the burden of VF among women in sub-Saharan Africa countries is largely unknown. The most recent community-based estimates of prevalence, drawing data from only two African countries (Ethiopia and the Gambia), are of 1·60 obstetric fistulas (95% Confidence Intervals (CI): 1·16-2·10) per 1,000 women of reproductive age [5].

Accurate estimates of the number and proportions of women suffering from this condition are especially difficult to obtain, as it is often the case with maternal morbidity indicators [6]. This is because the condition is rare and the affected women face considerable discrimination and marginalization [1,2]. In a 2007 review article, Stanton et al. [6] described three types of publications reporting on frequency, incidence, and prevalence of obstetric fistula. The first category of papers is mostly based on personal communications that report, without denominator, the number of patients treated. This is the approach used by the '*Global Fistula Map'* [7], developed by *Direct Relief* and the *Fistula Foundation* in partnership with the UNFPA, which maps the worldwide treatment capacity for VF and the number of corrective surgery performed each year. The second type of publication relies on declarations made by the authors themselves, or on "surgeons' estimates" but the source of data is often unclear. The third type, the least common, describes methods and provides appropriate denominators, albeit with varying degrees of transparency.

In sub-Saharan Africa, the two main sources of standardized nationally representative survey data are the USAID-sponsored DHS Program of Demographic and Health Surveys (DHS) and the UNICEF-sponsored Multiple Indicators Cluster Survey (MICS). In 2004, DHS started to include questions to estimate the prevalence of VF symptoms. However, a standardized VF module was only introduced after the recommendations of a 2006 expert meeting. Similarly, the fourth round of MICS surveys (2009-2011) included a reduced but comparable module of questions in a small number of countries. Some of these survey data have been used before to describe the scope and magnitude of the problem of VF [8-11]. However, only recently have a sufficiently large number of standardized surveys been conducted to enable their systematic cross-country analysis.

Using household surveys to estimate prevalence of VF and, more generally, maternal morbidity is challenging, however [12,13]. The survey's questions do not have the accuracy of the gold standard of a gynecological examination and an imperfect specificity could greatly overestimate prevalence of such a rare condition [14,15]. Sensitivity is not much cause for concern for VF since prevalence of this very rare outcome will be overwhelmingly conditioned by the survey instrument's specificity. Uncertainty remains, however, about the usefulness of self-reported VF symptoms since the validity of the DHS VF module has yet to be validated.

The primary aim of this paper is to estimate the prevalence of VF, adjusting for the imperfect specificity of the women's self-report of VF symptoms, by using all recent and available nationally representative surveys conducted in sub-Saharan Africa. The number of women currently suffering from VF symptoms is also estimated individually for each country with available data. Our secondary objectives are to characterize the respondents reporting VF symptoms and describe the profile of those who sought treatment.

METHODS

Data sources

All nationally representative DHS and MICS surveys from sub-Saharan Africa with available individual-data records were considered. Only surveys with questions about '*constant leakage of urine or stool through vagina*' or that incorporated in a VF module in the questionnaire were considered (Table 1). Both DHS and MICS are face-to-face household surveys administered to women of reproductive age (15 to 49 years of age). A thorough overview of these surveys has been presented elsewhere [16]. Briefly, DHS and MICS are household surveys that use a multistage, stratified sampling method to select a nationally representative sample of women aged 15-49 years old, excluding homeless and institutionalized individuals. The sampling process is generally stratified according to geographic region and/or degree of urbanization. A standard questionnaire is administered by trained staff to obtain information on socio-demographic characteristics, health indicators, and, in selected countries, self-reported symptoms of VF.

Prevalence of vaginal fistula

The list of fistula-related questions varied by survey, but for those with the VF module, respondents were queried about their knowledge of fistula, presence of fistula symptoms, presumed cause of their fistula, whether treatment was sought, and the outcome of this treatment. In addition, some of the DHS surveys and all MICS surveys used a contingency question about fistula knowledge before asking about presence of fistula symptoms. Probes were often used, as well as local terms to describe the condition (e.g., *maladie d'urine* in francophone countries). The complete list of probes and question for each survey, as well as the specific modules included in the questionnaires, can be found in the supplementary material (Tables S1 and S2). For surveys with a contingency question, we have assumed that, if a respondent had never heard of "*a problem such that [a woman] experience a constant leakage of urine or stool from her vagina during the day and night*", this respondent has never experienced symptoms of VF.

A small number of surveys only administered the fistula questions to women who had a live birth in the five years before the interview, to ever pregnant women, or to ever married women. Since these surveys used different population denominators, they were excluded from our prevalence estimates. For countries with more than one survey that recorded respondents' fistula symptoms, only the most recent survey was used to estimate prevalence.

Two main prevalence estimates will be reported in this study. First, we will estimate lifetime prevalence of fistula symptoms. This metric reflects the proportion of respondents who reported having ever experienced incontinence symptoms described by the survey question as "*uncontrollable [*or constant*] leakage of urine or stool from the vagina*". Second, we will estimate point prevalence (or current prevalence) of fistula symptoms. One survey explicitly asked if the women suffered from such symptoms at the time of interview (i.e., DRC DHS 2007) while others collected information on women who sought treatment for VF and the outcome of

such treatment. Only women who reported a complete remission (no more leakage of urine/stool) are considered cured of the condition and will therefore not be included in the numerator of point prevalence.

Using the 2010 population estimates from the UNDP World Population Prospects [17], we estimated for each country the number of women who ever experienced fistula symptoms and the number of women who currently have VF symptoms by multiplying these prevalence estimates by the country-specific number of women of reproductive age.

Statistical analyses

Prevalence

Prevalence estimates were computed for each country separately using the respondents' sampling weights. These proportions were then back-transformed to the number of women reporting VF symptoms and rounded to the nearest integer. This pre-processing step enabled us to take into account the respondent's differential inclusion probabilities in the surveys. Our preliminary analyses have shown that clustering of observations for lifetime prevalence of VF symptoms could be safely ignored as the estimated intra-class correlation coefficient [18] for this rare outcome is extremely small (i.e., 0·004) and the average number of women surveyed per cluster was also small (<30).

The pooled prevalence of VF was obtained using a flexible hierarchical Bayesian approach that allows one to easily incorporate sources of variation into the model [19,20]. To adjust for the imperfect nature of the survey instrument, the latent-class model described by Joseph *et al*. [21] was adapted to be used in a meta-analysis of prevalence data. The model assumes that each survey has its own true, but unobserved, prevalence and that the survey instruments have a common sensitivity and specificity. The relationship between these variables is expressed below:

$$P_o = \pi(Se) + (1-\pi)(1-Sp)$$

where P_o is the observed prevalence (as per the survey instrument), π is the true unobserved prevalence of the disease, *Se* is the survey instrument's sensitivity, and *Sp* is the instrument's specificity. Since the accuracy of the DHS/MICS VF questions has never been quantified, the uncertainty related to the sensitivity and specificity of the survey instrument was explicitly incorporated into our Bayesian meta-analysis. More specifically, we used a binomial distribution to model the number of women reporting VF symptoms (n_i). Each survey has its own prevalence (p_i), considered here as a random variable. The logit of this variable follows a normal distribution with mean υ and standard deviation σ. The complete model specification takes the following form:

Likelihood:

$$n_i \sim Binomial(p_i, N_i)$$

$$p_i = \pi_i(Se) + (1-\pi_i)(1-Sp)$$

$$\text{logit}(\pi_i) = \mu_i$$

$$\mu_i \sim N(\upsilon, \frac{1}{\sigma^2})$$

Prior distributions for model parameters and hyperparameters:

$$\upsilon \sim Normal(0,0.001)$$
$$\sigma \sim Uniform(0,100)$$
$$Se \sim Uniform(0.95,1)$$
$$Sp \sim Uniform(0,0.9995)$$

A non-informative prior was used for the mean (υ) of the logit-transformed individual prevalences (μ_i). Further, we assumed that the individuals survey's logit-transformed prevalence were drawn from a normal distribution with a standard deviation (σ) that has a non-informative uniform distribution. Priors for sensitivity (*Se*) and specificity (*Sp*) were elicited using uniform distributions. Based on subject matter knowledge, we assumed that sensitivity of the survey instrument would most likely fall in the 95%-100% range. For specificity, we premised that it would likely fall within the 0% to 99.95% range. In other words, this informative prior entails that we expect a minimum of 0.5 false positive per 1,000 interviewed women. (Note that using such a small value for the lower bound of the uniform distribution does not affect the posterior distribution of the prevalence estimate since a rare outcome entails that specificity cannot be lower than one minus the observed prevalence, see Supplemental Material.)

Among women reporting to have ever experienced VF symptoms, it was necessary to impute observations for a number of respondents who had missing information on whether treatment was sought and the outcome of this treatment. Further, five surveys recorded information on treatment seeking but not the outcome of this treatment. For these surveys, we imputed current prevalence based on the meta-analyzed proportion of successfully treated women. The model described above was modified to impute these responses by explicitly taking into account the associated uncertainty. This model is presented in more details in the supplementary material.

A number of surveys recorded information on the perceived cause of VF and whether the respondent sought treatment for this condition and the treatment's outcome. A hierarchical Bayesian meta-analysis approach was used to estimate the proportion of respondents that reported VF a symptoms who sought care, the proportion for which treatment resulted in complete remission, among women who did not seek care, the reason for not seeking treatment, and the self-reported cause of their VF symptoms. These meta-analyses used the same model specification described above, with the difference that it was not possible to adjust for imperfect sensitivity and specificity of the case definition since these questions were contingent on reporting VF symptoms.

Models were fitted using Markov Chain Monte Carlo simulations. Estimation of the posterior distribution of the parameters of interest was performed using JAGS [22,23]. Inferences were based on 200,000 iterations (an additional 50,000 iterations were used as burn-in). The '*rjags*' libray [24] was used to run JAGS using the R statistical software as an interface [25]. The median of the posterior distribution and its 95% credible intervals (CrI) are reported as summary estimates.

Role of the funding source

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

RESULTS

Surveys characteristics

A total of 29 population-based surveys conducted in sub-Saharan Africa included VF questions (Table 1). Individual-data records for the following surveys were not in the public domain and were therefore not included in our analyses: Equatorial Guinea (DHS 2011), Guinea-Bissau (MICS4 2010), and Mauritania (MICS4 2011). In addition, we deemed that the incontinence questions of the Ivory Coast 2011-12 DHS and the Malawi 2004 DHS surveys were too non-specific, as they referred to general incontinence (Supplementary material, Table S1), which could result from a number of other conditions [26]. Finally, the Mali DHS 2012-13 survey was also excluded because its sample was not nationally representative: almost half of the country's regions were not surveyed because of the armed conflict that prevailed at that time.

Hence, 23 surveys were considered in our analyses. Of these, we included 19 surveys in the meta-analysis of lifetime prevalence of VF (totaling 262,100 respondents), excluding those with different population denominators (Rwanda 2005 and Swaziland 2010) and only including the most recent survey per country (Niger 2012 and Uganda 2011). For point prevalence of VF symptoms, 14 surveys had information on current VF symptoms or treatment seeking and treatment outcome (141 responses with missing information were imputed). Point prevalence of the five remaining surveys that only recorded if treatment was sought was imputed based on overall treatment success (229 responses imputed). A map of countries with available data can be found in Figure 1.

Prevalence of vaginal fistulas and treatment-seeking

Lifetime prevalence of VF was estimated at 3·0 cases per 1,000 women of reproductive age (95%CrI: 1·3-5·5). Prevalence varied widely between countries with a low of 0·4 cases in Burkina Faso to a high of 19·2 cases per 1,000 women in Uganda (Figure 2). Point prevalence of VF symptoms is estimated at 1·0 cases per 1,000 women of reproductive age (95%CrI: 0·3-2·4) (Figure 3). If we replace our moderately informative prior for specificity with a completely vague prior that uniformly covers the 0%-100% range, the estimates for lifetime prevalence increases to 3·3 per 1,000 (95% CrI: 1·4-5·9) and to 1·4 per 1,000 (95% CrI: 0·4-2·9) for point prevalence (see Supplementary material, Tables S3 and S4). It is highly unlikely, however, that the VF questions could have a perfect specificity given that daily post-partum urinary incontinence was found to have a prevalence of 3% in a recent review [27] and that stress urinary incontinence in pregnant women is common [28,29]. We therefore preferred to report results from a more informative prior for this parameter (i.e., uniform over the 0%-99.95% range). Adjusting for the imperfect nature of the survey instruments improved prevalence estimates. In fact, assuming incorrectly a perfect sensitivity and specificity (uncorrected estimates), lifetime prevalence and point prevalence of VF symptoms would have been estimated at 4·4 per 1,000 (95%CrI: 2·9-6·5) and 2·1 per 1,000 (95%CrI: 1·2-3·3), respectively. The difference in prevalence between the corrected and uncorrected estimates entails that a substantial proportion of women reporting VF symptoms could be false positives.

Table 2 presents the respondents' characteristics of the 23 population-based national surveys, stratified by respondent's report of VF symptoms. This table shows that respondents reporting to have ever experienced VF symptoms are slightly older and generally reported having had more children than the women who do not report such symptoms. There was a tendency for illiteracy to be associated with VF symptoms but the differences were most often not statistically

significant. The association between reports of VF symptoms and living in an urban area and age at first birth was highly variable between countries.

Using the 2010 population estimates for the number of women of reproductive age in each of the 19 countries considered in this study, we estimated that Uganda and Ethiopia had the largest number of women of reproductive age who ever experienced lifetime VF symptoms with 140,500 (95% CrI: 109,700-173,800) and 142,100 (95% CrI: 120,300-166,100) women, respectively (Table 3). Ethiopia also has the largest burden of VF with an estimated of 110,800 (95% CrI: 85,500-140,100) women of reproductive age who currently experience VF symptoms.

The great majority of fistulas (81·4%) were reported to have resulted from a pregnancy, followed by 'other causes' (8·6%), pelvic operations/surgeries (4·6%), sexual assaults (3·6%), and 'unknown causes' (1·8%) (Table 4, scaled estimates; Figures S1-S5 in supplementary material, unscaled estimates). The proportion of fistulas that have resulted from a sexual assault was highest in DRC, 22%. Among the 19 surveys that recorded if treatment was sought, 70·3% (95%CrI: 61·2%-78·7%) of women who ever suffered from VF symptoms reported having sought treatment (any type) (Figure 4). A total of 13 surveys collected information on treatment outcome and, among women who reported having sought treatment, 74·7% (95%CrI: 69·2%-79·9%) had a complete remission - defined as no more leakage of urine or stool (Figure 5). The reasons most often mentioned for not having sought treatment were costs (18·8%; 95%CrI: 7·8%-32·4%), not knowing where to find treatment (18·3%; 95%CrI: 6·8%-32·1%), not knowing the condition was curable (17·5%; 95%CrI: 3·7%-34·7%), and feeling too embarrassed to consult (10·9%; 95%CrI: 6·2%-17·2%) (Table 5).

Table 6 describes the characteristics of women who have and have not sought treatment for their VF symptoms. Those not reporting having sought care were generally younger and of lower socio-economic status. Again, the direction of association varied greatly by country.

DISCUSSION

This meta-analysis of national household surveys from sub-Saharan Africa has shown that 3·0 per 1,000 women of reproductive age (95% CrI: 1·3-5·4) had suffered from VF symptoms during their lifetime and that 1·0 per 1,000 women of reproductive age currently suffer from such symptoms (95% CrI: 0·3-2·4). We estimated that Ethiopia had the largest number of women of reproductive age who currently experience VF symptoms (110,800), followed by Uganda (74,200). To the best of our knowledge, this study reports the first estimate of VF burden in sub-Saharan Africa based on recent large-scale national survey data. Our estimated point prevalence of women who currently suffer from VF symptoms is consistent with the sub-Saharan Africa figure reported in Adler *et al*.'s global systematic review [5] (1·6 per 1,000 women of reproductive age) which were based on only two countries (Ethiopia and the Gambia). Another commonly used estimate of prevalence comes from the 2000 update of the Global Burden of Disease. Their estimate assumed that 2·15% of neglected obstructed labor would result in an VF, yielding an prevalence of 1·88 per 1,000 women between the ages of 15-44 years old in sub-Saharan Africa [30]. Our study shows that prevalence of VF using women's self-reports is lower than previously reported, but these previous estimates are within our credible intervals.

The great majority of women with VF symptoms reported that the cause of their fistula was pregnancy-related. Sexual assaults were not a common cause of VF, except in countries that have experienced armed conflicts such as the Democratic Republic of Congo [31,32], with 21% of women with VF symptoms reporting that the cause of their condition was a sexual assault. Of all

women reporting having experienced VF symptoms, 70·3% reported having sought any form of treatment. This proportion might include women seeking care through traditional healers that can do little when modern health system interventions are required to repair VF. Among women having sought care, 74·7% reported a complete remission. This proportion is consistent with the rate of successful surgeries reported in the fistula literature taking into account that several surgeries are sometimes needed for complete remission [33-35] and that a small, yet unknown, proportion of fistulas are deemed incurable within the challenging health system conditions and low resource contexts of sub-Saharan Africa [36,37]. Our results suggest that costs and knowing that effective surgery exists (and where to get it) are the main barriers to treatment-seeking.

Despite our findings being consistent with previous studies and our understanding of the etiology of VF, some important limitations need to be acknowledged. Our results should be analyzed in view of constraints that both DHS and MICS may experience when collecting information on a sensitive and stigmatizing disease [16]. Being household-based surveys, such data could underestimate prevalence if a substantial number of women with VF are homeless, ostracized within their own family [38], or housed in long-term care facilities dedicated to fistula patients [39]. This should mostly affect our estimates for point prevalence, however. Second, only women of reproductive age were interviewed despite the facts that women older than 50 years of age, and those younger than 15 years of age, could also experience VF symptoms. Third, we have assumed in our adjustments that the surveys all had a common sensitivity and specificity. This assumption was required to ensure model identifiability. Even if DHS and MICS surveys used a standardized methodology, we cannot rule out that the quality of a questionnaire's translation in local languages could have resulted in different sensitivity/specificity of the VF questions. In addition, the respondents' understanding of the question and familiarity with the topic of VF could have also varied between region and country. This could partly explain why the recorded prevalence in the Uganda DHS 2011 is many times higher than that of the other countries, despite our adjustments. Excluding this latter survey from the meta-analyses only had a minor impact on our overall summary measures, however, with estimates of 2·8 per 1,000 (95% CrI: 1·2-4·9) and 0·9 per 1,000 (95% CrI: 0·2-2·1) for lifetime and point prevalence, respectively. Fourth, our credible intervals were not adjusted for the complex survey design and this could potentially underestimate the sampling variance. Nonetheless, using the design-based adjustment of Korn and Graubard [40], which substitutes the original sample size for a degrees-of-freedom adjusted effective sample size, had a negligible impact on the width of the credible interval for lifetime prevalence of VF symptoms (this adjustment was unfortunately not possible to implement for point prevalence due to the imputation of missing observations). Finally, DHS/MICS data provides lifetime and not lifecourse information. Profile differences between women reporting VF symptoms and those who did not, as well as those who did and did not sought treatment, need to be interpreted with caution. For example, the important proportion of women reporting VF who reside in urban in certain countries could have resulted from greater accessibility of VF treatment services in urban centers. Additionally, these descriptions are limited by the fact that the case definition likely includes a high proportion of false positives.

This study also has a number of strengths. First, our prevalence estimates are based on 19 nationally representative surveys. Responses from 262,100 women, including 1,341 women reporting having ever experienced VF symptoms, were pooled. As such, we have improved on earlier estimates by considerably expanding the number of countries represented. We have also incorporated uncertainty of the survey's instrument imperfect accuracy into our analyses, as well as the uncertainty in the imputation of missing observations for point prevalence through a

cohesive Bayesian approach. We conducted a sensitivity analysis for the type of prior distributions used for sensitivity and specificity and showed that lifetime prevalence of VF is most likely below 3·3 per 1,000 (95%CrI: 1·4-5·9) and point prevalence below 1·4 per 1,000 (95% CrI: 0·4-2·9).

In conclusion, this study has shown that the point prevalence of VF is slightly lower than previously reported. This could have resulted from the continued improvements of maternal health indicators in sub-Saharan Africa over the last decade [41,42] and increased availability of and accessibility to corrective surgery [43,44]. Despite the high uncertainty related to our estimates, we have shown that national household surveys based on self-reports of VF symptoms can sometimes be used to estimate disease burden. Given the potentially high rate of false positives, estimates should be adjusted for the imperfect specificity of the questionnaires.

RESEARCH IN CONTEXT

Systematic review

Vaginal fistula (VF) continues to affect the health and lives of many women in the most deprived parts of the world. As a public health and reproductive health right issue, VF embodies many of the challenges faced by the post-2015 maternal health agenda in sub-Saharan Africa (how to ensure timely access to emergency obstetric care, address the shortages of skilled human resources, improve quality of care within low-resource health systems, and maintain the rights of to reproductive health care during their whole life). Over the last decade, an international campaign has boosted fistula prevention, treatment and research. Yet, the planning and evaluation of fistula interventions have been hampered by the lack of reliable prevalence estimates.

We did not aim to do a comprehensive systematic review of VF prevalence as a recent systematic review has been conducted which identified only two robust population based studies in African countries[5]. Rather we aim to fill an evidence gap by conducting a comprehensive analysis of existing primary data sources. Nevertheless, we searched PubMed, Web of Knowledge, and Google Scholar with the Terms ("Obstetric fistula" OR "Vesico-vaginal fistula" OR "Vesicovaginal fistula" OR "Recto-vaginal fistula" OR "Rectovaginal fistula" OR "Genito-urinary fistula" OR "Genitourinary fistula") AND ("Prevalence" OR "Incidence"). This search confirmed the lack of population based estimates on fistula in African countries, except for the two non-DHS studies identified by Adler *et al*. [5], and DHS-type data. Adler *et al.* [5] had rejected all studies based on self-reports of fistula in light of concerns over the accuracy of maternal morbidity questionnaires. Taking into account these concerns, we used a Bayesian approach to estimate the pooled prevalence from DHS/MICS surveys as this enabled us to incorporate uncertainty over the survey's instrument accuracy.

Interpretation

Overall, the lifetime prevalence of VF symptoms in sub-Saharan Africa was 3·0 per 1000 women (95% CrI: 1·3-5·5) and the point prevalence was 1·0 per 1000 women (95% CrI: 0·3-2·4). Ethiopia has the largest number of women who experience VF symptoms, followed by Uganda. The prevalence of VF using women's self-reports is lower than previously reported, but these previous estimates are within our credible intervals. We have improved on earlier estimates by considerably expanding the number of countries represented. However, our results should be interpreted with caution considering the potential limitation of DHS/MICS in surveying a rare and ostracizing condition such as fistula. While vaginal fistula is a relatively rare event, its occurrence remains too frequent in African countries.

COMPETING INTERESTS

The authors have declared that they have no competing interests.

AUTHORS' CONTRIBUTIONS

FKS developed the original research idea with contributions by SS, MMG, and VF. FKS and SS performed the background literature review for this paper. MMG assembled and managed the databases, specified the Bayesian models, and performed the meta-analyses with contributions by FKS. MMG and FKS drafted the manuscript. MCC, N Maulet, N Meda, and VF contributed intellectual content to the paper and critically reviewed it. All authors have read and approved the final version of this manuscript.

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References

Table 1: Availability of nationally representative surveys with vaginal fistula (VF) related questions in sub-Saharan Africa.

Country / Survey	Individual data record availability	Eligibility for VF questions (proportion of total sample eligible)
Benin DHS 2011-12	Yes	All women aged 15-49 (100%)
Burkina Faso DHS 2010	Yes	All women aged 15-49 (100%)
Cameroon DHS 2011	Yes	All women aged 15-49 (100%)
Chad MICS 2010	Yes	With knowledge of fistula (20.3%)
Comoros DHS 2012	Yes	All women aged 15-49 (100%)
Congo (Brazz.) DHS 2011-12	Yes	All women aged 15-49 (100%)
DRC DHS 2007	Yes	With knowledge of fistula (8.0%)
Ivory Coast DHS 2011-12*	Yes	All women aged 15-49 (100%)
Equatorial Guinea DHS 2011	No	All women aged 15-49 (100%)
Ethiopia DHS 2005	Yes	With knowledge of fistula (23.2%)
Guinea DHS 2012	Yes	All women aged 15-49 (100%)
Guinea-Bissau MICS4 2010	No	Ever pregnant (NA%)
Kenya DHS 2008-09	Yes	All women aged 15-49 (100%)
Malawi DHS 2004*	Yes	All women aged 15-49 (100%)
Malawi DHS 2010	Yes	All women aged 15-49 (100%)
Mali DHS 2006	Yes	With knowledge of fistula (16.4%)
Mali DHS 2012-13§	Yes	All women aged 15-49 (100%)
Mauritania MCIS4 2011	No	Ever married & with knowledge of fistula (NA%)
Niger DHS 2006	Yes	With knowledge of fistula (37.9%)
Niger DHS 2012	Yes	With knowledge of fistula (44.1%)
Nigeria DHS 2008	Yes	All women aged 15-49 (100%)
Rwanda DHS 2005	Yes	Had live birth in last 5 year (47.9%)
Senegal DHS 2010-11	Yes	All women aged 15-49 (100%)
Sierra Leone DHS 2013	Yes	All women aged 15-49 (100%)
Swaziland MICS 2010	Yes	Ever pregnant & with knowledge of fistula (18.8%)
Tanzania DHS 2010	Yes	All women aged 15-49 (100%)
Togo MICS 2010	Yes	With knowledge of fistula
Uganda DHS 2006	Yes	All women aged 15-49 (100%)
Uganda DHS 2011	Yes	All women aged 15-49 (100%)

VF=Vaginal Fistula; DRC=Democratic Republic of the Congo.
*Fistula module was not included but a question regarding 'incontinence' was asked.
§ The sample of the Mali DHS 2012-13 is not nationally representative.

Table 2: Characteristics of respondents for each of the 23 household surveys with questions about lifetime vaginal fistula (VF) symptoms, stratified by women's report of VF symptoms.

Country	Sample size (Un-weighted)		Mean age (Years)*		Proportion illiterate*		Proportion living in urban areas*		Mean number of children Ever born*		Mean age (years) at 1st birth*¶	
	VF	Not VF	VF	Not VF	VF	Not VF	VF	Not VF	VF	Not VF	VF	Not VF
Benin DHS 2011-12	127	16,472	28·6	28·9	70·4%	72·4%	**61·6%**	**46·3%**	2·4	2·7	20·1	20·0
Burkina Faso DHS 2010	20	17,042	**33·6**	**28·8**	**57·9%**	**82·8%**	42·9%	27·1%	3·3	3·3	19·8	19·0
Cameroon DHS 2011	56	15,363	**31·0**	**27·9**	37·6%	40·0%	**68·2%**	**53·8%**	3·2	2·7	19·5	18·8
Chad MICS 2010	40	15,817	29·1	27·8	83·6%	85·8%	**45·5%**	**24·9%**	4·1	3·9	**12·9**	**18·4**
Comoros DHS 2012	110	5,213	**30·5**	**27·6**	57·4%	46·2%	**51·8%**	**32·8%**	**3·1**	**2·1**	20·3	20·6
Congo (Brazz.) DHS 2011-12	27	10,791	30·0	28·6	25·5%	25·6%	70·8%	68·6%	2·7	2·5	**17·5**	**19·1**
DRC DHS 2007	44	9,942	30·0	28·3	38·7%	51·3%	44·5%	45·4%	4·2	3·0	18·4	19·2
Ethiopia DHS 2005	103	13,952	**32·6**	**28·0**	81·5%	78·1%	19·2%	17·7%	**4·4**	**3·1**	18·3	18·5
Guinea DHS 2012	63	9,073	30·6	28·4	81·6%	79·7%	43·5%	36·3%	3·2	3·0	18·9	18·2
Kenya DHS 2008-09	78	8,358	**32·6**	**28·4**	36·1%	26·2%	16·0%	25·5%	**3·9**	**2·7**	19·0	19·2
Malawi DHS 2010	132	22,878	29·2	28·0	**51·1%**	**40·6%**	10·7%	18·7%	3·3	3·1	19·1	18·4
Mali DHS 2006	18	14,562	**34·3**	**28·4**	100·0%	88·0%	26·8%	33·7%	**5·6**	**3·6**	19·1	18·2
Niger DHS 2006	20	9,169	28·4	28·6	95·7%	92·5%	22·2%	19·5%	3·7	4·0	18·0	17·8
Niger DHS 2012	16	11,138	28·7	28·8	100·0%	89·2%	0·0%	18·8%	4·8	4·2	16·9	18·2
Nigeria DHS 2008	142	33,175	**30·8**	**28·7**	57·2%	52·5%	30·2%	35·7%	**3·6**	**3·1**	19·0	19·4
Rwanda DHS 2005 §	164	5,222	**29·1**	**31·3**	52·0%	44·4%	9·9%	14·4%	3·7	4·2	20·7	21·1
Senegal DHS 2010-11	18	15,670	31·7	27·9	72·1%	71·1%	55·2%	49·3%	3·5	2·5	19·4	19·7
Sierra Leone DHS 2013	112	16,431	**30·3**	**28·4**	78·9%	68·5%	44·9%	35·4%	**3·6**	**2·9**	**17·8**	**18·7**
Swaziland MICS 2010 §	57	3,261	**34·8**	**31·7**	16·2%	12·3%	19·6%	30·5%	**4·0**	**3·0**	**29·5**	**26·5**
Tanzania DHS 2010	51	10,085	30·8	28·6	36·1%	33·0%	34·1%	28·5%	2·9	2·9	18·7	19·0
Togo MICS 2010	23	6,352	32·9	29·2	78·4%	57·9%	29·3%	45·3%	**4·1**	**2·7**	19·0	19·7
Uganda DHS 2006	201	8,275	**30·8**	**28·0**	**60·2%**	**51·0%**	10·7%	17·0%	**4·7**	**3·5**	18·1	18·2
Uganda DHS 2011	164	8,442	**31·0**	**28·0**	51·5%	48·5%	**11·4%**	**19·9%**	**4·4**	**3·4**	17·9	18·2

VF=Respondents reporting having ever experienced vaginal fistula symptoms; Not VF=Respondents reporting never having experienced vaginal fistula symptoms; DRC=Democratic Republic of Congo.

Statistical differences at the α=0·05 significance level are bolded. Significance of differences between means was assessed using design-based t-test. For proportions, we used the χ^2 statistics and the Rao-Scott adjustment for the complex survey design.

* Characteristics of respondents were adjusted using the women's survey weight.

¶ Excluding nulligravidae women.
§ Note that the Rwandan and Swazi surveys have different denominators: women with a live birth in preceding 5 years and ever pregnant women, respectively.

Table 3: Estimates of the number of women of reproductive age (15-49 years of age) who ever experienced vaginal fistula (VF) symptoms and who currently experience VF symptoms in 19 sub-Saharan countries.

Country	Number of women who ever experienced VF symptoms		Number of women who currently experienced VF symptoms	
	Median	(95% CrI)	Median	(95% CrI)
Benin DHS 2011-12	14,600	(11,500-18,000)	9,600	(7,300-12,300)
Burkina Faso DHS 2010	1,500	(100-4,000)	500	(0-2,000)
Cameroon DHS 2011	15,500	(10,000-21,400)	1,900	(100-5,000)
Chad MICS 2010	4,900	(2,300-7,500)	800	(0-2,500)
Comoros DHS 2012	2,300	(1,800-2,900)	1,200	(900-1,700)
Congo (Brazz.) DHS 2011-12	1,600	(600-2,800)	100	(0-600)
DRC DHS 2007	25,200	(9,000-43,100)	14,200	(3,600-27,700)
Ethiopia DHS 2005	140,500	(109,700-173,800)	110,800	(85,500-140,100)
Guinea DHS 2012	13,900	(9,800-18,700)	8,300	(53,00-11,900)
Kenya DHS 2008-09	90,100	(69,400-113,700)	49,900	(34,000-69,200)
Malawi DHS 2010	16,900	(13,100-20,900)	5,200	(3,200-7,500)
Mali DHS 2006	2,300	(200-4,900)	300	(0-1,500)
Niger DHS 2012	2,800	(400-6,200)	900	(0-3,000)
Nigeria DHS 2008	115,200	(82,400-147,700)	46,800	(28,000-67,800)
Senegal DHS 2010-11	1,500	(100-3,800)	300	(0-1,400)
Sierra Leone DHS 2013	8,500	(6,600-10,600)	4,100	(2,900-5,600)
Tanzania DHS 2010	55,300	(39,400-73,400)	21,400	(10,800-34,700)
Togo MICS 2010	3,700	(1400-6,300)	1,500	(200-3,500)
Uganda DHS 2011	142,100	(120,300-166,100)	74,200	(56,000-95,700)

VF=Vaginal fistula; 95% CrI= 95% credible intervals.

Table 4: Meta-analysis results from 15 surveys of self-reported causes of vaginal fistulas symptoms (N=889)·

Causes of vaginal Fistulas	Number women reporting vaginal fistula symptoms	Percentage* (95% CrI)	Scaled percentages§
Pregnancy-related	605	72·0% (59·4%-82·1%)	81·4%
Sexual assault	56	3.2% (0·7%-7·2%)	3·6%
Pelvic operation	40	4·1% (2·1%-6·5%)	4·6%
Other	68	7·6% (4·0%-13·2%)	8·6%
Does not know	124	1·6% (0·0%-9·3%)	1·8%

95%CrI=95% credible intervals
The 15 included surveys are: Benin DHS 2011-12, Burkina Faso DHS 2010, Cameroon DHS 2011, Comoros DHS 2012, Congo (Brazz.) DHS 2011-12, Democratic Republic of Congo DHS 2007, Guinea DHS 2012, Kenya DHS 2008-09, Malawi DHS 2010, Mali DHS 2006, Niger DHS 2012, Nigeria DHS 2008, Senegal DHS 2010-11, Sierra Leone DHS 2013, Tanzania DHS 2010.
*Percentages across survey obtained through hierarchical Bayesian meta-analysis.
§The percentages of vaginal fistulas attributable to each cause were scaled in order to sum to one.

Table 5: Meta-analysis results for mains reason women with self-reported vaginal fistulas symptoms did not seek treatment.

Reasons for not seeking care (not mutually exclusive)	Nb. of surveys with response option	Nb. not seeking care by reason / Total not seeking care	Percentage* (95% CI)
Too Expensive	12	68/291	18·8% (7·8%-32·4%)
Does not know where to go§	11	62/284	18·3% (6·8%-32·1%)
Thought it was not curable	12	65/291	17·5% (3·7%-34·7%)
Too Embarrassed§	10	30/268	10·9% (6·2%-17·2%)

95%CI=95% confidence intervals
Note that the reasons for not seeking care are not mutually exclusive and that not all surveys listed the same response options.
*Percentage across survey obtained by random-effect meta-analysis.

Table 6: Characteristics of women reporting vaginal fistulas symptoms that have sought care (Tx) for this condition and those that did not (No Tx).

Country	Sample size (Un-weighted)		Mean age (Years)*		Proportion illiterate*		Proportion in bottom quintile of SES (poorest)*		Proportion living in urban areas*	
	Tx	No Tx	Tx	No Tx	Tx	No Tx	Tx	No Tx	Tx	No Tx
Benin DHS 2011-12	56	71	30·0	27·5	71·8%	69·3%	13·0%	10·5%	55·6%	66·5%
Burkina Faso DHS 2010	8	5	33·6	28·1	62·8%	35·4%	11·6%	0·0%	55·9%	52·3%
Cameroon DHS 2011	33	7	31·1	32·5	32·8%	56·6%	**1·3%**	**20·9%**	72·4%	57·2%
Chad MICS 2010	32	6	29·6	28·9	81·4%	91·8%	17·7%	23·2%	**52·7%**	**12·5%**
Comoros DHS 2012	67	33	30·9	29·4	47·0%	69·3%	12·9%	28·4%	52·7%	53·1%
Congo (Brazz.) DHS 2011-12	19	2	30·4	26·8	22·2%	0·0%	10·9%	55·0%	80·7%	45·0%
DRC DHS 2007	31	12	28·6	31·7	38·1%	55·7%	13·5%	12·4%	46·8%	58·1%
Ethiopia DHS 2005	33	67	36·1	31·2	86·8%	80·1%	18·3%	23·3%	29·1%	13·8%
Guinea DHS 2012	37	24	30·8	30·5	85·2%	74·0%	**13·8%**	**47·8%**	47·1%	33·8%
Kenya DHS 2008-09	47	31	**35·6**	**28·6**	35·8%	36·4%	10·9%	13·0%	19·3%	11·6%
Malawi DHS 2010	108	24	**29·9**	**25·4**	53·1%	39·0%	25·1%	17·9%	11·0%	8·5%
Mali DHS 2006	16	2	35·0	30·9	100·0%	100·0%	26·6%	100·0%	32·4%	0·0%
Niger DHS 2006	4	3	28·5	30·0	100·0%	100·0%	32·8%	66·7%	7·1%	0·0%
Niger DHS 2012	15	1	**28·0**	**35·0**	100·0%	100·0%	19·2%	0·0%	0·0%	0·0%
Nigeria DHS 2008	62	23	30·6	31·6	70·6%	57·4%	34·2%	18·2%	25·2%	28·5%
Rwanda DHS 2005 §	57	106	28·1	29·7	51·3%	52·8%	**10·4%**	**25·6%**	12·0%	8·8%
Senegal DHS 2010-11	12	6	30·7	35·6	68·3%	86·0%	26·4%	50·9%	60·4%	35·8%
Sierra Leone DHS 2013	68	35	31·0	28·6	76·9%	85·6%	14·1%	22·7%	46·8%	38·2%
Tanzania DHS 2010	18	6	33·1	26·5	31·5%	64·2%	21·9%	24·7%	24·7%	37·6%
Togo MICS 2010	14	9	34·1	31·2	76·5%	81·2%	**5·4%**	**40·6%**	36·4%	18·8%
Uganda DHS 2011	98	66	32·1	29·1	56·7%	42·8%	18·0%	18·5%	13·3%	8·3%

Statistical differences at the α=0·05 significance level are bolded. Significance of differences between means was assessed using design-based t-test. For proportions, we used the χ^2 statistics and the Rao-Scott adjustment for the complex survey design.

* Women's characteristics take into account sampling weights.

§ Note that the Rwanda DHS 2005 survey has a different denominator (i.e., women with a live birth in preceding 5 years).

Figure legends:

Figure 1: Sub-Saharan Africa countries where nationally-representative household surveys with questions on vaginal fistula symptoms were conducted.

Figure 2: Lifetime prevalence of vaginal fistula symptoms per 1,000 women of reproductive age in sub-Saharan Africa (2005-2012).

Figure 3: Point prevalence of vaginal fistula symptoms per 1,000 women of reproductive age in sub-Saharan Africa (2005-2012). Countries marked with an asterisk indicate that the survey did not recorded information on whether the treatment for vaginal fistula symptoms was successful. These responses were imputed based on treatment success rate from other countries.

Figure 4: Proportion of women reporting vaginal fistula symptoms who sought care for this condition (2005-2012).

Figure 5: Proportion of women who reported having sought care for their vaginal fistula symptoms for whom the treatment resulted in complete remission (2008-2012).

SUPPLEMENTARY ONLINE MATERIAL

This supplementary material is arranged in five sections. The first section present the incontinence questions and probes related to vaginal fistula (VF) symptoms from 29 household surveys conducted in sub-Saharan Africa (Table S1). To avoid translation errors, these questions/probes have been left in the language in which they were abstracted from the questionnaire (i.e., English, French, Portuguese, or Spanish). The second section details the list of VF-related questions, such as presumed cause of VF symptoms, treatment seeking, and treatment outcome, included in each survey (Table S2). The third section described the model used for imputation of missing observations for point prevalence. In the fourth section, the forest plots for self-reported cause of VF symptoms are presented (Figure S1 to S5). Finally, in the fifth section, results from the sensitivity analyses for the different prior specifications are presented (Tables S3 and S4).

SECTION 1

Table S1: Specific incontinence questions and probes related to vaginal fistula symptoms in questionnaires from household surveys conducted in sub-Saharan Africa (in original language).

Country	Probe / Contingency	Question
Benin (DHS) 2011-12	Les femmes peuvent parfois avoir, en permanence, le jour et la nuit, un problème de pertes urinaires ou fécales par le vagin. Ce problème survient généralement à la suite d'un accouchement difficile, mais il peut aussi se produire après une agression sexuelle ou après une opération du pelvis.	Avez-vous déjà eu, en permanence, durant le jour et la nuit, des pertes urinaires ou fécales par le vagin?
Burkina Faso (DHS) 2010	Les femmes peuvent parfois avoir, en permanence, le jour et la nuit, un problème de pertes urinaires ou fécales par le vagin. Ce problème survient généralement à la suite d'un accouchement difficile, mais il peut aussi se produire après une agression sexuelle ou après une opération du pelvis.	Avez-vous déjà eu, en permanence, durant le jour et la nuit, des pertes urinaires ou fécales par le vagin?
Cameroon (DHS) 2011	Une femme peut parfois avoir des écoulements constants d'urine où d'excréments à partir de son vagin. Ce problème survient généralement après un accouchement difficile, un viol ou une opération chirurgicale pelvienne.	Avez-vous déjà eu un écoulement constant d'urine ou d'excréments à partir de votre vagin?
Chad (MICS) 2010	**Contingency**: Connaissez-vous une maladie appelé fistule, c.-à.-d. la maladie de l'urine?	Avez-vous déjà souffert ou souffrez-vous actuellement de cette maladie?
Comoros (DHS) 2012	Une femme peut parfois avoir des écoulements constants d'urine ou d'excréments à partir de son vagin. Ce problème survient généralement après un accouchement difficile, un viol ou une opération chirurgicale pelvienne.	Avez-vous déjà eu un écoulement constant d'urine ou d'excréments à partir de votre vagin?
Congo (DHS) 2011-12	Une femme peut parfois avoir des écoulements constants d'urine ou d'excréments à partir de son vagin. Ce problème survient généralement après un accouchement difficile, un viol ou une opération chirurgicale pelvienne.	Avez-vous entendu parler de ce genre de problème, je veux dire d'une femme qui a des écoulements constants d'urine ou d'excréments à partir de son vagin?
Congo DR (DHS) 2007	**Contingency**: Connaissez-vous la maladie dénommée "fistule" c'est-à-dire, la maladie qui fait que la femme perd de l'urine et/ou défèque continuellement?	Connaissez-vous (souffrez-vous) actuellement de pertes d'urines et/ou de selles par le vagin en dehors des "mictions /défécations"?
Ivory Coast (DHS) 2011-12	None	Avez-vous déjà eu des problèmes d'incontinence d'urine ou de selles?

Equatorial Guinea (DHS) 2011	Las mujeres pueden a veces tener, permanentemente, de día y de noche, un problema de pérdidas urinarias y/o fecales por la vagina. Este problema ocurre generalmente tras un parto difícil, pero puede también producirse después de una agresión/violencia sexual o después de una operación del pelvis.	¿Ya tuvo usted, permanentemente, durante el día y la noche, de las pérdidas urinarias o fecales por la vagina?
Ethiopia (DHS) 2005	**Contingency:** Have you ever heard of obstetric fistula (use local term)? If no, probe: Have you ever heard of a condition in which a woman continuously leaks urine and/or faeces following childbirth?	Have you yourself experienced obstetric fistula?
Guinea (DHS) 2012	Une femme peut parfois avoir des écoulements constants d'urine ou d'excréments à partir de son vagin. Ce problème survient généralement après un accouchement difficile, un viol ou une opération chirurgicale pelvienne.	Avez-vous déjà eu un écoulement constant d'urine ou d'excréments à partir de votre vagin?
Guinea-Bissau (MICS4) 2011	As vezes uma mulher pode ter um probldma, depois do parto dificil, que ela sofre um vazamento de urina ou fezes na vagina durante o dia e noite.	**Já** teve este problema?
Kenya (DHS) 2008-09	Sometimes a woman can have a problem such that she experiences a constant leakage of urine or stool from her vagina during the day and night. This problem usually occurs after a difficult childbirth, but may also occur after a sexual assault or after a pelvic surgery.	Have you ever experienced a constant leakage of urine or stool from your vagina during the day and night?
Malawi (DHS) 2004	**1st question**: None **Probe for 2nd question**: Sometimes a woman can have a problem, usually after a difficult childbirth, such that she experiences a leakage of urine or stool from her vagina.	**1st question**: After this birth, did you experience a problem such as: leakage of urine or stool from your vagina? **2nd question**: Have you ever experienced this problem?
Malawi (DHS) 2010	Sometimes a woman can have a problem such that she experiences a constant leakage of urine or stool from her vagina during the day and night. This problem usually occurs after a difficult childbirth, but may also occur after a sexual assault or after a pelvic surgery.	Have you ever experienced a constant leakage of urine or stool from your vagina during the day and night?
Mali (DHS) 2006	**Contingency**: Connaissez-vous la maladie dénommée 'fistule' c'est-à-dire, la 'maladie de l'urine'?	Avez-vous déjà contracté cette maladie?
Mali (DHS) 2012-13	**Contingency**: Les femmes peuvent parfois avoir, en permanence, le jour et la nuit, un problème de pertes urinaires ou fécales par le vagin. Ce problème survient généralement à la suite d'un accouchement difficile, mais il peut aussi se produire après une agression sexuelle ou après une opération du pelvis.	Avez-vous déjà eu, en permanence, durant le jour et la nuit, des pertes urinaires ou fécales par le vagin?
Mauritania (MICS4) 2011	**Contingency:** Connaissez-vous la maladie dénoméée fistule, c'est-à-dire "maladie de l'urine" survenue suite à un accouchement compliqué?	Êtes-vous atteinte ou avez-vous déjà contractée cette maladie?
Niger (DHS) 2006	**Contingency:** Connaissez-vous la maladie dénommée 'fistule' c'est-à-dire, la 'maladie de l'urine'?	Êtes-vous atteinte ou avez-vous déjà contracté cette maladie?
Niger (DHS) 2012	**Contingency:** Connaissez-vous la maladie dénommée 'fistule' c'est-à-dire la 'maladie de l'urine'?	Etes-vous atteinte ou avez-vous déjà contracté cette maladie?

Nigeria (DHS) 2008	Sometimes a woman can have a problem such that she experiences a constant leakage of urine or stool from her vagina during the day and night. This problem usually occurs after a difficult childbirth, but may also occur after a sexual assault or after a pelvic surgery. This is called vesicovaginal fistula (VVF).	Have you ever experienced a constant leakage of urine or stool from your vagina during the day and night?
Rwanda (DHS) 2005	Sickness characterized by the incontrollable flow of urine and/or feces from the vagina due to a perforation in the wall of the vagina.	Have you ever suffered from an obstetrical fistule?
Senegal (DHS) 2010-11	Les femmes peuvent parfois avoir, en permanence, le jour et la nuit, un problème de pertes urinaires ou fécales par le vagin. Ce problème survient généralement à la suite d'un accouchement difficile, mais il peut aussi se produire après une agression sexuelle ou après une opération du pelvis.	Avez-vous déjà eu, en permanence, durant le jour et la nuit, des pertes urinaires ou fécales par le vagin?
Sierra Leone (DHS) 2013	**Contingency:** Sometimes a women can have a problem of constant leakage of urine or stool from her vagina during the day and night. This problem usually occurs after a difficult childbirth, but may also occur after a sexual assault or after pelvic surgery.	Have you ever experienced a constant leakage of urine or stool from your vagina during the day and night?
Swaziland (MICS) 2010	**Contingency:** Sometimes, after a difficult childbirth, a woman can experience a constant leakage of urine or stool from her vagina during the day or night. Have you ever heard of this problem?	Have you ever suffered from or are you suffering from this condition?
Tanzania (DHS) 2010	Sometimes a woman can have a problem such that she experiences a constant leakage of urine or stool from her vagina during the day and night. This problem usually occurs after a difficult childbirth, but may also occur after a sexual assault or after a pelvic surgery.	Have you ever experienced a constant leakage of urine or stool from your vagina during the day and night?
Togo (MICS) 2010	**Contingency:** Connaissez-vous une maladie appellée fistule vésico-vaginale?	En avez-vous déjà souffert?
Uganda (DHS) 2006	Sometimes a woman can have a problem, usually after a difficult childbirth, in which she experiences uncontrollable leakage of urine or stool from her vagina.	Have you ever experienced this problem?
Uganda (DHS) 2011	Sometimes a woman can have a problem of constant leakage of urine or stool from her vagina during the day and night. This problem usually occurs after a difficult childbirth, but may also occur after a sexual assault or after pelvic surgery.	Have you ever experienced a constant leakage of urine or stool from your vagina during the day and night?

SECTION 2

Table S2: Availability of household surveys with questions on vaginal fistula (VF) in sub-Saharan Africa.

Country	Survey Type	Heard of VF	VF Status	Age when VF	Cause of VF	Sought Treatment	Outcome of Treatment
Benin 2011-12	DHS	✓	✓		✓	✓	✓
Burkina Faso 2010	DHS	✓	✓		✓	✓	✓
Cameroon 2011	DHS	✓	✓		✓	✓	✓
Chad 2010	MICS4	✓	✓			✓	
Comoros 2012	DHS	✓	✓		✓	✓	✓
Congo Brazzaville 2011-12	DHS	✓	✓		✓	✓	✓
DRC 2007	DHS	✓	✓	✓	✓	✓	
Cote d'Ivoire 2011-12	DHS		✓				
Equatorial Guinea 2011	DHS	✓	✓		✓	✓	✓
Ethiopia 2005	DHS	✓	✓			✓	
Guinea 2012	DHS	✓	✓		✓	✓	✓
Guinea-Bissau 2010	MICS4	✓	✓	✓	✓	✓	✓
Kenya 2008-09	DHS		✓		✓	✓	
Malawi 2004	DHS		✓				
Malawi 2010	DHS	✓	✓		✓	✓	✓
Mali 2006	DHS		✓		✓	✓	✓
Mali 2012-13	DHS	✓	✓		✓	✓	✓
Mauritania 2011	MICS4	✓	✓			✓	✓
Niger 2006	DHS	✓	✓		✓	✓	✓
Niger 2012	DHS	✓	✓	✓	✓	✓	✓
Nigeria 2008	DHS	✓	✓		✓	✓	✓
Rwanda 2005	DHS		✓			✓	
Senegal 2010-11	DHS	✓	✓		✓	✓	✓
Sierra Leone 2013	DHS	✓	✓		✓	✓	✓
Swaziland 2010	MICS4	✓	✓				
Tanzania 2010	DHS	✓	✓		✓	✓	✓
Togo 2010	MICS4	✓	✓			✓	
Uganda 2006	DHS		✓				
Uganda 2011	DHS		✓			✓	

VF=Vaginal fistula; DRC= Democratic Republic of the Congo.

SECTION 3

The Bayesian model specification for the random effect meta-analysis of point prevalence with imputation of missing observations takes the following form:

$$(n_i + n_i^*) \sim Binomial(p_i, N_i)$$
$$p_i = \pi_i * Se + (1 - \pi_i)(1 - Sp)$$
$$\text{logit}(\pi_i) = \mu_i$$
$$\mu_i \sim Normal(\upsilon, \frac{1}{\sigma^2})$$

where n_i is the number of women who currently experienced VF symptoms in survey i; n_i^* is the imputed number of women who currently experienced VF symptoms; and N_i is denominator for prevalence. This remaining of this latent-class model specification is the same as the one described in the main paper. Imputing responses for the number observations with missing information on whether treatment was sought (NAs_i) or whether treatment was successful (NAt_i) is done through the following equation:

$$n_i^* = NAs_i * (1 - \psi_i) + NAs_i * \psi_{ii} * (1 - \phi_i) + NAt_i * (1 - \phi_i)$$

where ψ_i is the country-specific proportion of women with VF symptoms who reported having sought treatment; and ϕ_i is the proportion of women who reported a complete remission after having sought treatment. These logit-transformed survey-specific proportions (Ψ_i and Φ_i) follow a normal distribution with mean ω and standard deviation o, and with mean φ and standard deviation ϑ for having sought treatment and reporting a complete remission, respectively.

$$ns_i \sim Binomial(\psi_i, Ns_i)$$
$$\text{logit}(\psi_i) = \Psi_i$$
$$\Psi_i \sim Normal(\omega, \frac{1}{o^2})$$
$$nt_i \sim Binomial(\phi_i, Nt_i)$$
$$\text{logit}(\phi_i) = \Phi_i$$
$$\Phi_i \sim Normal(\varphi, \frac{1}{\vartheta^2})$$

It should be noted that, for the five surveys that did not recorded information on treatment outcome, nt_i was replace with the missing value indicator (i.e., '*NA*') and the Bayesian model automatically imputed ϕ_i based on the overall distribution. The specification is completed through the following priors for the model's parameters and hyperparameters:

$$\upsilon \sim Normal(0, 0.001)$$
$$\sigma \sim Uniform(0, 100)$$
$$Se \sim Uniform(0.95, 1)$$
$$Sp \sim Uniform(0, 0.9995)$$
$$\omega \sim Normal(0, 0.001)$$
$$\varphi \sim Normal(0, 0.001)$$
$$o \sim Uniform(0, 100)$$
$$\vartheta \sim Uniform(0, 100)$$

Country	VF Caused by Pregnancy	Total VF	Percentage (95% CrI)
Comoros DHS 2012	43	107	41.5 (32.5–50.8)
Benin DHS 2011–12	53	127	42.8 (34.4–51.4)
Cameroon DHS 2011	28	56	51.8 (39.1–64.2)
Burkina Faso DHS 2010	7	15	52.9 (30.4–74.0)
DRC DHS 2007	24	44	56.4 (42.1–69.9)
Congo (Brazz.) DHS 2011–12	12	20	62.7 (42.6–79.9)
Mali DHS 2006	13	18	72.7 (52.5–87.7)
Senegal DHS 2010–11	13	18	72.7 (52.3–87.7)
Niger DHS 2012	12	16	74.7 (53.6–89.5)
Sierra Leone DHS 2013	81	102	79.1 (70.8–86.1)
Malawi DHS 2010	102	122	83.2 (76.1–89.0)
Tanzania DHS 2010	25	28	86.4 (72.5–95.0)
Nigeria DHS 2008	72	82	86.8 (78.7–92.8)
Guinea DHS 2012	56	63	87.4 (78.3–93.8)
Kenya DHS 2008–09	64	71	88.7 (80.5–94.4)
Summary	**605**	**889**	**72.0 (59.4–82.1)**

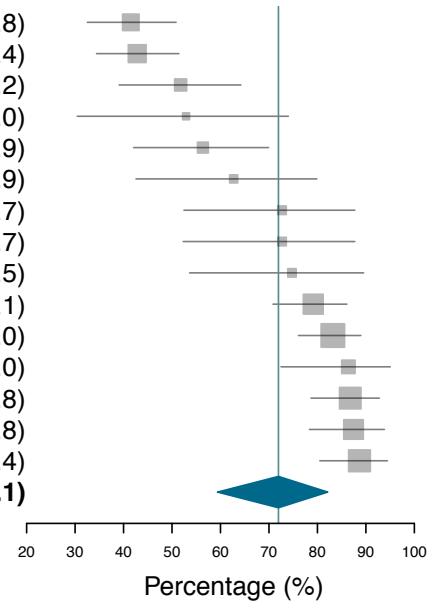

Figure S1: Proportion of vaginal fistulas for which the presumed self-reported cause was pregnancy-related.

Country	VF Sexual Assault Cause	Total VF	Percentage (95% CrI)
Sierra Leone DHS 2013	0	102	0.6 (0.0–3.2)
Tanzania DHS 2010	0	28	1.2 (0.0–7.2)
Senegal DHS 2010–11	0	18	1.5 (0.0–9.3)
Mali DHS 2006	0	18	1.5 (0.0–9.3)
Niger DHS 2012	0	16	1.6 (0.0–9.9)
Burkina Faso DHS 2010	0	15	1.6 (0.0–10.2)
Kenya DHS 2008–09	1	71	1.6 (0.2–5.7)
Malawi DHS 2010	3	122	2.4 (0.7–5.9)
Congo (Brazz.) DHS 2011–12	1	20	3.8 (0.4–14.8)
Guinea DHS 2012	4	63	5.5 (1.8–12.5)
Nigeria DHS 2008	6	82	6.5 (2.7–13.0)
Comoros DHS 2012	9	107	7.7 (3.8–13.6)
Cameroon DHS 2011	6	56	9.2 (3.7–18.2)
Benin DHS 2011–12	15	127	11.0 (6.5–17.2)
DRC DHS 2007	11	44	21.8 (11.5–35.6)
Summary	**56**	**889**	**3.2 (0.7–7.2)**

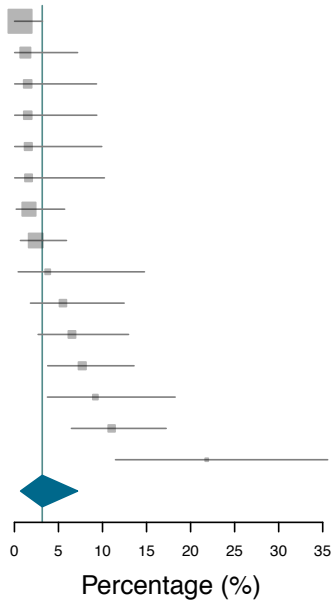

Figure S2: Proportion of vaginal fistulas for which the presumed self-reported cause was a sexual assault.

Country	VF Cause Operation	Total VF	Percentage (95% CrI)
Comoros DHS 2012	1	107	2.3 (0.5–5.3)
Sierra Leone DHS 2013	1	102	2.4 (0.5–5.4)
Guinea DHS 2012	1	63	3.0 (0.7–6.7)
Mali DHS 2006	0	18	3.3 (0.5–8.9)
Niger DHS 2012	0	16	3.3 (0.5–9.2)
Kenya DHS 2008–09	2	71	3.5 (1.0–7.3)
Malawi DHS 2010	5	122	4.0 (1.8–7.6)
Congo (Brazz.) DHS 2011–12	1	20	4.2 (1.1–11.7)
Senegal DHS 2010–11	1	18	4.3 (1.1–12.5)
Cameroon DHS 2011	3	56	4.5 (1.7–10.1)
Tanzania DHS 2010	2	28	4.9 (1.6–12.9)
Nigeria DHS 2008	5	82	5.0 (2.3–10.2)
Benin DHS 2011–12	10	127	6.4 (3.5–11.4)
DRC DHS 2007	5	44	7.0 (3.1–16.4)
Burkina Faso DHS 2010	3	15	7.5 (2.8–24.6)
Summary	**40**	**889**	**4.1 (2.1–6.5)**

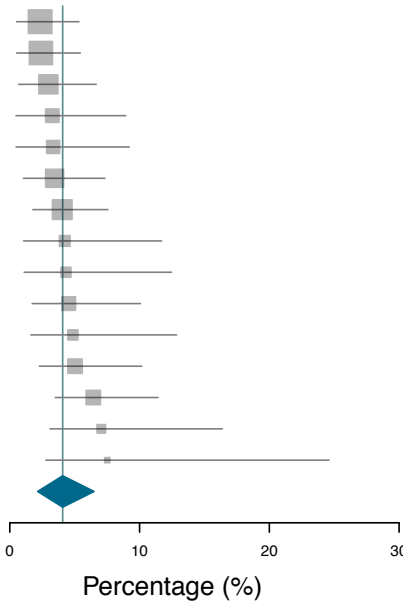

Figure S3: Proportion of vaginal fistulas for which the presumed self-reported cause was a pelvic operation/surgery.

Country	VF Other Cause	Total VF	Percentage (95% CrI)
Nigeria DHS 2008	0	82	1.8 (0.2–5.7)
Sierra Leone DHS 2013	2	102	2.9 (0.8–6.9)
Guinea DHS 2012	1	63	3.0 (0.6–8.1)
Benin DHS 2011–12	7	127	5.6 (2.6–10.2)
Kenya DHS 2008–09	4	71	5.8 (2.2–12.0)
Tanzania DHS 2010	2	28	6.9 (1.9–17.5)
DRC DHS 2007	4	44	8.3 (3.2–17.6)
Cameroon DHS 2011	5	56	8.4 (3.5–16.5)
Senegal DHS 2010–11	2	18	9.0 (2.5–23.7)
Comoros DHS 2012	11	107	9.8 (5.3–16.0)
Burkina Faso DHS 2010	2	15	10.0 (2.7–26.8)
Malawi DHS 2010	13	122	10.1 (5.8–16.0)
Niger DHS 2012	4	16	17.3 (6.1–38.3)
Mali DHS 2006	5	18	19.9 (7.6–40.5)
Congo (Brazz.) DHS 2011–12	6	20	22.1 (9.0–42.6)
Summary	**68**	**889**	**7.6 (4.0–13.2)**

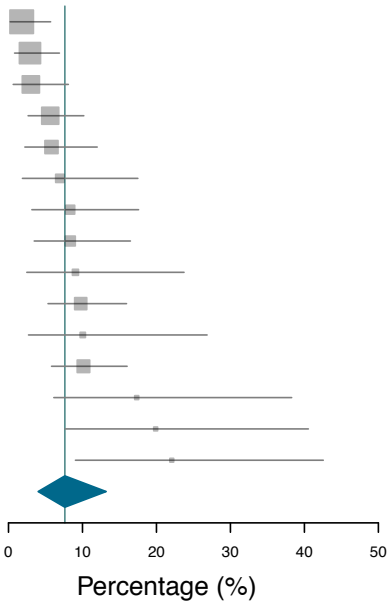

Figure S4: Proportion of vaginal fistulas for which the presumed self-reported cause was any other events.

Country	VF Unknown Cause	Total VF	Percentage (95% CrI)
Malawi DHS 2010	0	122	0.1 (0.0–1.5)
Nigeria DHS 2008	0	82	0.1 (0.0–2.1)
Kenya DHS 2008–09	0	71	0.1 (0.0–2.4)
DRC DHS 2007	0	44	0.2 (0.0–3.6)
Tanzania DHS 2010	0	28	0.2 (0.0–5.1)
Congo (Brazz.) DHS 2011–12	0	20	0.3 (0.0–6.7)
Niger DHS 2012	0	16	0.3 (0.0–8.0)
Guinea DHS 2012	1	63	1.2 (0.1–5.8)
Mali DHS 2006	1	18	3.7 (0.2–18.1)
Senegal DHS 2010–11	3	18	14.1 (3.4–34.5)
Burkina Faso DHS 2010	3	15	16.9 (4.1–40.2)
Sierra Leone DHS 2013	18	102	17.2 (10.8–25.2)
Cameroon DHS 2011	13	56	22.3 (12.8–34.4)
Benin DHS 2011–12	42	127	32.7 (24.9–41.1)
Comoros DHS 2012	43	107	39.8 (30.8–49.2)
Summary	**124**	**889**	**1.6 (0.0–9.3)**

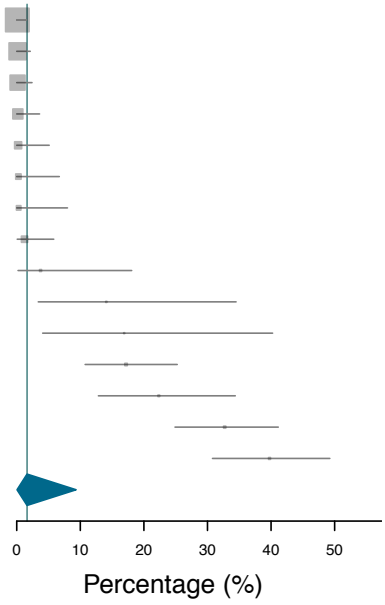

Figure S5: Proportion of vaginal fistulas for which the presumed self-reported cause unknown.

SECTION 5

The results from the sensitivity analyses of different prior specifications for lifetime and point prevalence of VF symptoms are presented in Tables S3 and S4, respectively. Priors for sensitivity (using a uniform distribution) were varied from a 95%-100% range to a 90%-100% and a 85%-100% range. For specificity, we varied the range from 0%-99.95% to a completely uninformative prior in the 0%-100% range, to a more informative prior in the 0%-99.96% range, and to an even more informative prior in the 0%-99.94%. For this latter prior, it is implicitly assumed that we expect a minimum of 0.6 false positive per 1,000 interviewed women. We also included a prior for specificity in the 98.01%-99.95% range and 98.94%-99.95% ranges for lifetime and point prevalence, respectively, to show that setting the lower bound to 1 minus the maximum survey-specific observed prevalence does not impact our results.

Table S3: Sensitivity analyses examining the impact of different prior specifications on estimates of lifetime prevalence of vaginal fistula symptoms.

Prior for Sensitivity (Uniform)	**Prior for Specificity (Uniform)**	**Lifetime Prevalence per 1,000 women of reproductive age (95% CrI*)**
Priors used in the paper		
U(0·95, 1)	U(0, 0·9995)	3·0 (1·3-5·5)
Changing the prior for sensitivity		
U(0·90, 1)	U(0, 0·9995)	3·1 (1·3-5·6)
U(0·85, 1)	U(0, 0·9995)	3·2 (1·4-5·8)
Changing the prior for specificity		
U(0·95, 1)	U(0, 1)	3·3 (1·4-5·9)
U(0.95, 1)	U(0, 0.9996)	3·1 (1·3-5·5)
U(0.95, 1)	U(0.9801, 0.9995)	3·0 (1·3-5·5)
U(0·95, 1)	U(0, 0·9994)	2·9 (1·2-5·4)

*95% CrI=95% Credible Intervals

Table S4: Sensitivity analyses examining the impact of different prior specifications on estimates of point prevalence of vaginal fistula symptoms.

Prior for Sensitivity (Uniform)	**Prior for Specificity (Uniform)**	**Point Prevalence per 1,000 women of reproductive age (95% CrI*)**
Priors used in the paper		
U(0·95, 1)	U(0, 0·9995)	1·0 (0·3-2·4)
Changing the prior for sensitivity		
U(0·90, 1)	U(0, 0·9995)	1·0 (0·3-2·4)
U(0·85, 1)	U(0, 0·9995)	1·0 (0·3-2·5)
Changing the prior for specificity		
U(0·95, 1)	U(0, 1)	1·4 (0·4-2·9)
U(0·95, 1)	U(0, 0·9996)	1·1 (0·3-2·5)
U(0.95, 1)	U(0.9894, 0.9995)	1·0 (0·3-2·4)
U(0·95, 1)	U(0, 0·9994)	0·9 (0·2-2·2)

*95% CrI=95% Credible Intervals